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THE LABORATORIES OF THE TECHNICAL SECTION OF AERONAUTICS
("SERVICE TECHNIQUE DE L'AÉRONAUTIQUE" or "S.T.Aé.")

By Lieut. Col. Robert.

From "L'Aéronautique," December 15, 1922 - January 2, 1923.

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THE LABORATORIES OF THE TECHNICAL SECTION OF AERONAUTICS

("SERVICE TECHNIQUE DE L'AÉRONAUTIQUE" or "S.T.Aé.")*

By Lieut. Col. Robert.

HISTORICAL SKETCH.

Before the war, the Aeronautical Department had only two small laboratories. They were situated respectively at Chalais-Meudon and Vincennes, the latter being used for aviation work, and the former more especially for aerostation.

In 1914, the work was stopped and the personnel scattered. Very soon, however, the military authorities perceived what an important rôle aviation was going to play and, in a very short time, aeronautical industries developed to an altogether unforeseen extent. It was found necessary to set up a strict inspection of all raw material employed, and there arose the need of organizations for giving practical form to the designs drawn up to meet the new requirements of each day. In industrial problems, the engineer who has to study out a new design may base it on any mechanism, device, or method of procedure resulting from previous research work and which is on very much the same lines as the required design. He has then only to modify or complete it, in order to adapt it to the new demands. In aviation, however, such is not the case, as nearly all the problems presented are entirely new.

At the end of 1915, it was therefore decided, in order to meet requirements, to organize the laboratories as follows:

*From "L'Aéronautique," December 15, 1922 - January 2, 1923. pp. 373-378.

1st. A test and experimental department at Chalais Meudon with laboratories belonging to the "Service des Fabrications" (Manufacturing Section);

2nd. The utilization of outside laboratories, such as those of the "Conservatoire des Arts et Métiers" (Conservatory of Arts and Trades), Museum, Mint, the laboratory of the High School of Electricity, etc.

The two laboratories at Chalais were intended for mechanical tests on metals, woods, and other raw materials, and for chemical tests. All other research work had to be done outside, especially aerodynamical work, which was done in the only two private aerodynamical laboratories in France - the Eiffel laboratory and the laboratory of the Aerotechnical Institute of St. Cyr, belonging to the University of Paris.

During the period when all organizations were vying with each other in working for national defense, it was easy for the S.T.Aé. (Technical Section of Aeronautics) to make use of outside premises and plants, but from the beginning of 1919 such premises were reclaimed, one after the other, by their owners, until, in July of the same year, not one was left at the disposal of the S.T.Aé.

About the same time, all the engineers, chemists and experimenters who, at the end of the war had been detailed to laboratory service were demobilized, and the S.T.Aé. found its laboratories and research bureaus almost stripped of scientific personnel. The work had, therefore, to be started pretty much

all over again, both as regards premises and trained personnel.

A complete organization has been in course of formation at Issy-les-Moulineaux for the last three years, and is now almost completed. In fact, the need of means for thorough research work had been recognized as early as 1917 and it had been decided to establish at Issy-les-Moulineaux an aeronautical center combining research bureaus, workshops, and laboratories.

Such a Government Establishment, combining all three branches of the work, does not exist either in Germany, England, or Italy. In Germany, the work is distributed among constructors, such as Zeppelin, Junkers, etc., and among the technical laboratories of the various universities (Göttingen, Bonn, Aix-la-Chapelle, Leipzig). In England, an attempt was made to centralize the work at Farnborough, but part of the research work, especially the part relating to aerodynamics, is done in the National Physical Laboratory.

The system adopted in Germany would not be possible, were it not for the fact that manufacturers and universities are both willing to work under the control and direction of the government. It has perhaps the advantage of bringing aeronautical questions more to the front among students and young engineers, but on the other hand, it leads to much dispersion of personnel and matériel. This system also demands that all the workers shall submit to the same discipline, in order that the work may be done with unity of purpose, following the same program and adopting the same methods. In France, the national charac-

ter is more independent and there is more personal initiative so that it would not be so easy for Frenchmen to adapt themselves to this way of working. On the other hand, the separation of the departments, as in England, would result in a lack of coordination.

It would appear that, taking into account our temperament, our individualism, and the absolute necessity of getting the most we can for our money, our solution of the problem is the best. All the various departments are therefore combined into one government establishment and placed under one management, whose duty is to direct all efforts towards the attainment of clearly defined aims. These departments are:

The Designing Department, comprising various bureaus charged with the preparation of technical questions, with the examination of projects drawn up by private firms, or with the drawing up of complete projects;

Workshops for turning out working models of the drawings. They may even make a model airplane, but do not undertake quantity production;

A Testing Department for testing finished work, that is, for making flight tests of airplanes and bench tests of engines;

A Research and Laboratory Department.

Here we will only deal with the last-named department, which comprises:

1st. An aerodynamic laboratory;

2nd. A laboratory for mechanical tests and heat treatment

of metals;

3rd. A chemical laboratory, in which are tested such raw materials as fabrics, wire, rubber, etc.;

4th. A laboratory of physical and applied mechanics;

5th. A standardization laboratory, for determining or verifying the dimensions of parts (chiefly of engines) designed for quantity production.

We will give a brief account of the equipment of each of these laboratories and of the work which is done in them. In a general way this work comes under the two following categories:

1st. Control tests or researches requested by the various sections of the S.T.Aé. or other aeronautical department ("Service des Fabrications," "Direction de l'Aéronautique Militaire," (Department of Military Aeronautics) "Service de la Navigation Aérienne," (Aerial Navigation Section) etc.) or by airplane builders. In general, these are the current tests requested by the various departments as the need arises. In most cases they must be undertaken and completed with all possible speed;

2nd. Laboratory research work, regarding the utilization of new materials, or scientific questions of all kinds, the solution of which would aid progress in aviation. These researches, like all scientific work, must be carried out methodically and not hampered by too strict limitation of time.

AERODYNAMIC LABORATORIES.

These hold the first place in the laboratory organization of the S.T.Aé., as well on account of their material develop-

ment and the importance to aviation of the problems they alone can solve, as on account of the fact that none of the research departments of scientific or industrial establishments possesses such laboratories. The limits of this article do not permit giving even a short description of them and their work, which will be the subject of a later article.

At the present time, the S.T.Aé. has at its disposal the Eiffel Laboratory at Auteuil and the laboratory of the Aero-technical Institute at St. Cyr. Since airplane constructors have no wind tunnel at their disposal, all tests requested by their research departments are made, free of charge, by the S.T.Aé., in one of these two laboratories.

A large wind tunnel, the most powerful of its kind either in Europe or America, has just been completed at Issy-les-Moulineaux and will be used early in 1923. This wind tunnel has a force of 1000 HP and produces an airstream 3 meters in diameter with a velocity of 80 to 85 m/sec., or about 300 km. (186 miles) an hour.

LABORATORY FOR MECHANICAL TESTS AND HEAT TREATMENTS.

This laboratory comprises two sections: one for metals, and one for woods. It occupies two buildings, each covering an area of 350 square meters (about 3770 sq.ft.). In the metal-testing building, the equipment consists of machines of the most modern type. We may mention four machines with a universal device for tensile, bending, and compression tests. Two of these are 50-ton machines. There are two impact test ma-

chines and machines for simple torsion tests, rotary bending tests and repeated impact tests. There are also special devices for testing finished parts, such as airplane propellers and wheels.

One room is reserved for microscopic metallography, a method of investigation for obtaining information concerning the crystalline structure of metals (steel, brass, bronze, aluminum alloys) and consequently concerning the heat treatments to which they have been subjected. The apparatus employed is the Chatelier micrographic bench. In the same room there is a "Saladin" device and a Chevenard differential dilatometer for determining the critical temperatures or transformation points of metals.

Another room is specially fitted up for the study of heat treatments, the equipment including a series of gas furnaces. Of these, one has a hearth 1.4 meters deep, for large parts, such as crankshafts. Another is a muffle furnace, in which are treated parts subject to oxydation or reduction under the influence of burnt gases. In these two furnaces the temperature ranges from 900° to 1000°C . There are also two small muffle furnaces for test specimens. In these a temperature of 1200° can be obtained. The equipment also includes oil and water tempering vats, a salt-bath furnace for tempering up to 600° , a smokeless forge and several pyrometric recording devices. All the furnaces are connected with a large pipe placed in the ground, through which a pump draws off the burnt gases and dis-

charges them into the air through a central chimney.

The fabrics used on airplanes directly affect their safety in flight and therefore the chemical and mechanical tests of textiles are of special importance. A room is reserved for these tests and is equipped with special tensile testing machines (two of the S.T.Aé. type and three Chevefy dynamometers).

The section for investigations concerning the employment of wood in the construction of airplanes is not very large nor has it a very extensive equipment, but its rôle nevertheless, is a very important one. The methodical work of Mr. Monnin, Inspector of Waters and Forests, has, for the first time, thrown light on the mechanical tests of woods. This work, now well known to all experts, has served as the basis of specifications for aviation woods, and even for the specifications drawn up by the Permanent Standardization Committee of the Ministry of Commerce for the general employment of woods.

The Laboratory of Mechanical Tests is now almost exclusively utilized for the control tests required for the acceptance of matériel by the "Service des Fabrications." In 1921, more than 600 tests of metal or wood were made, 700 of fabrics, cords and wires, and 80 of machined parts (wheels, propellers, turnbuckles, etc.).

An excellent measure has been adopted by the "Service des Fabrications," and is now being applied, namely, to require airplane constructors to install machines for making the usual mechanical tests. In this way, the "Service des Fabrications" can

test, on the spot, the materials used in construction and, on the other hand, the S.T.Aé., relieved of the greater part of the customary tests, can give more time to general research work and to special tests.

Among the latter, we may mention those for determining the causes of rupture or of abnormal wear of parts leading to accidents while running. The results of these tests are extremely instructive, for, by means of them, the quality of manufacture can be followed up in the laboratory and the information thus obtained leads to a constant improvement in construction. For instance, if a crankshaft breaks during flight, it is examined in order to discover the cause of failure. In one, the failure of which had caused a serious accident, it was found that the crank-pin journal had broken near the middle. The color of the metal and traces of anti-friction metal incrustated on the journal near the break indicated that the accident was due to friction from insufficient lubrication. The mechanical tests (tensile strength, hardness, resilience) of test-pieces, followed by the chemical analysis of the metal and its micrographic examination, showed that there was also another reason for the failure. The metal used was a special steel of a composition adapted to the purpose for which it was employed, but the heat treatment had been unsatisfactory. The heating after tempering had been carried too far, resulting in a real annealing.

The use of light aluminum and magnesium alloys requires much research work with these metals. It is necessary to study

their general mechanical properties and the best heat treatment, their deterioration by atmospheric agencies or by sea water and how to prevent such deterioration, the conditions under which these alloys age and the influence of great variations of temperature (from -50 to $+50^{\circ}\text{C}$) on their mechanical properties, the effect of repeated impacts and of vibrations (coming from the engine) on their crystalline structure, also riveting and welding.

Special test methods have been instituted for certain airplane parts; such as wheels and propellers. By placing them under actual working conditions, we can determine the number of kilogram-meters absorbed before rupture, as compared with their weight in kilograms.

PHYSICAL AND MECHANICAL LABORATORY.

This laboratory occupies a one-story building having an area of 350 sq.m. Every room is supplied with gas and water and with electric wires for direct and alternating currents. It will be permanently equipped for making the most common tests and the apparatus will be kept in working order, so that the tests can be made without delay. The tests in question may be classified as follows:

Tests of Materials and Chemicals.

Apparatus for Physico-Chemical Tests.

Molecular and Thermal Measurements. - Apparatus for measuring viscosity and lubricating power. - Besides the usual apparatus, there is an instrument for the direct measurement of viscosity.

This instrument is the result of researches made last year by the Faculty of Sciences, Paris, and will enable the standardization and calibration of practical viscosimeters. There will also be instruments for measuring capillary tension, specific heat, coefficients of expansion and melting points.

Optical Measurements.— These measurements are chiefly intended for identifying chemicals where they play an important rôle. Besides an ordinary spectroscope, a large quartz spectograph will enable identifications in the ultra-violet rays. This is supplemented by a high frequency transformer for the study of the spectra of metal sparks. The data given by the usual refractometers and diasporameters will be checked by means of a standard goniometer acquired for the purpose of studying the identification of carbides by the specific dispersions. A large standard polariscope will be used for measuring natural rotary powers and also for magneto-optical and electro-optical measurements. The above-mentioned instruments will be supplemented by nephelometric measuring devices for studying chemical changes manifested by variations of transparency.

Electric and Magnetic Measurements.— These consist especially of permanent outfits for the following purposes: Measurement of the differences of contact potential, especially for the study of alloys; measurement of the insulation of specific inductive capacities, of dielectric polarization, and of permeability. There are also high voltage transformers and a continuous high tension outfit by electronic rectifiers and condensers.

Apparatus for Testing the Instability of Substances.- These tests are made by accentuating the causes of physical deterioration to which materials are subjected and which act slowly under actual working conditions. The equipment comprises hot ovens, ovens cooled by a refrigerating machine, and chambers for illumination by ultra-violet rays.

Apparatus for Thermodynamic Measurements of Carburizing Agents.- To supplement the measurements on engines made by the Engine Testing Department, instruments are provided for measuring calorific capacity, steam pressure, heat of vaporization, etc.

Tests and Studies of Mechanism.- The permanent equipment comprises, in particular: an outfit for verifying the accuracy and stability of gyrostatic devices; a device for checking the mechanisms of clocks and tachometers; a device for the methodical production of perturbing periodic motions (at well-defined rates of acceleration) and for estimating the effect of such perturbations on the measuring instruments; a device for testing and studying synchronizing and clockwork mechanisms.

Tests and Studies of Instruments and Electric Outfits for Use on Aircraft.- Outfit for the study of the functioning of thermometers, barometers, and altimeters under the influence of simultaneous variations of pressure and temperature. Study of the compass under similar conditions. Outfit for testing and studying spark plugs, heating apparatus and electric generators.

OPTICAL AND PHOTOGRAPHIC LABORATORY.

This also occupies a single-story building with an area of 350 sq.m. The optical and photographic problems presented by aviation and especially those relating to aerial photography are almost always of a very special character and therefore require a special laboratory. It contains all the modern instruments for measurements of all kinds on lenses, cameras, searchlights and optical recording devices. There are special sensitometric devices for research work in physico-chemistry and photo-chemistry relative to photographic emulsions.

There is an optical bench 9 meters long for optical measurements of long focus lenses (lenses of cameras for aerial photography) and of lenses of small curvature (searchlights). It is so made and adjusted that the slide is perfectly horizontal; at no point does this slide deviate from the mean horizontal by more than one-twentieth of a millimeter.

The sensito-metric testing methods with a great quantity of light necessitate the measurement of short, uniform periods of time, and especially their repetition, and this is accomplished by means of a device of which the essential part is a flywheel with a diameter of two meters and weighing 1000 kg. (about 2200 lbs).

For experiments which must be made in darkness, there are dark rooms entered by zigzag passages. Such experiments may last for weeks.

STANDARDIZATION LABORATORY.

The essential work of this laboratory is to establish and

keep all standard gages and check the jigs required for quantity production (chiefly of engine parts). Here also are adjusted all the measuring instruments required for supplementing the measurements of the standard gages. It is not yet fitted up for taking direct measures of length; all the measurements are made by comparison with Johanson gages.

The comparison instruments are:

A length comparator, by which a difference of one-thousandth of a millimeter can easily be detected. The original measurement is fixed by a level which determines the error (plus or minus) of the magnitude to be compared, and by which the base measurement can be repeated at any moment;

A spherometer, likewise measuring to one-thousandth of a millimeter;

A special instrument designed and constructed in the laboratory which, by a combination of optical and mechanical processes, measures the angles of a screw thread, their position on the axis, the various taperings, and the pitch;

A device which projects on a screen a greatly enlarged representation of any profile, particularly of screw threads.

The laboratory makes, or causes to be made, standard gages in duplicate, one of which is kept as a reference, and the other is used for copying. The laboratory also attends to the checking of gages, issuing certificates of examination and stamping those found to be accurate.

CHEMICAL LABORATORY.

This laboratory occupies a building having an area of 350 sq.m. There is also an open space roofed over for experiments which emit poisonous or bad-smelling gases. It has all the usual rooms, such as a store-room for chemicals and glass ware, a weighing room, a room fitted up for electrolytic analyses, etc.

The three principal rooms are equipped for the three principal kinds of work done in the laboratory: analyses of metals and alloys; analyses and experiments with fuels and lubricants; analyses and experiments with dopes, varnishes, and paints.

In 1921 the acceptance tests of all substances of this kind used in the construction of airplanes included 510 tests of samples of acetyl-cellulose dope and varnish, 40 tests of gasoline and oil, and 70 of metals and alloys.

Among the more general experiments necessitated by the use of these substances in aviation we may mention:

Substitution of new synthetic resin dopes for acetate of cellulose dopes which are not sufficiently water-proof;

Experiments with a varnish for fabrics covered with gold-beater's skin for use on airships;

Study of the effect on linen fabrics of free acetic acid in acetate of cellulose dopes;

Investigation of various hydrocarbons in gasoline. Determination of the respective percentages of the different series of carbides (cyclic, acyclic, ethylenic, and aromatic) and of the proportions of each of the carbides of the different series.

These were found by the method of the critical temperatures of solution;

Establishment of methods of analysis for new light alloys of aluminum or magnesium.

The Government Laboratories of the S.T.Aé. will be able to meet the requirements of the various aeronautical departments, both as regards the buildings and their equipment, which consists of the most modern machines and instruments.

In conclusion, I must say a word regarding the very important question of personnel. At the present time, there is a small nucleus of experts - university men, engineers from the "Ecole Centrale" and other technical schools. Also, when special questions are to be studied, the help of scientists and engineers from outside is obtained.

But, if the laboratories are to be as efficient as they should be, considering their size, equipment, and the amount of money spent on them, the personnel must be considerably augmented. After all the debates on "the sad state of the French laboratories" proved that there were plenty of capable scientists but that they did not have the material means to work with, it would be truly paradoxical, now that the means are provided, if we should not have the brain power to make the most of them.

This question, however, is in a fair way to be settled satisfactorily, for, in the 1923 budget, Parliament has just voted the increased appropriation for personnel requested by the Under Secretary of State for Aeronautics and Aerial Transportation.

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